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The Issue of Soft Rocks Causing Problems in Foundation Engineering

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Abstract

Heterogeneity of the geological environment causes different problems related to foundation engineering. Every engineering-geological condition requires specific solutions. The occurrence of soft rock is a risk, especially in interaction with other actors. Among the so-called soft rocks are organic soil, clay and loam (silt), lacustrine sediments, but also soft soils in connection with phase changes in frozen or defrost environments. In connection with these problematic soils, questions of low bearing capacity, different settlement, landslides, heterogeneity of the geological environment and others are solved. The aim of the publication is to highlight the possible occurrence, the most common risks during interaction of this type of geological environment with engineering construction. A series of case studies and investigations of different countries are mentioned in this publication. Creating a simple scheme of soft rock and summarizing the basic problems of soft rock serves as a generalization of this problem. However, it should be understood that each foundation soil is located in a different environments, which is also influenced by other factors.

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Keywords: soft rock; clays; loam; organic soil; lacustrine sediments.

1. Introduction

The occurrence of soft rocks [fig.1] poses the environment for an engineering geologist, geotechnical and civil engineers that need increased attention. The issue of foundation engineering or the problems of existing buildings on soft ground are present worldwide and were described in numerous publications. Some selected cases of the

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problem of soft rocks are listed here. Each geological environment is very special, because in addition to the type of rocks, hydrological conditions, terrain topography, climatic conditions, type of construction and many others play an important role. However, it is possible to create analogies in a number of points and to learn from these cases.
Development of technologies in the field of soil improvement and foundation engineering is evolving rapidly. At present, we can build objects on the rocks, which were previously unsuitable for the construction of buildings. It is a question of the construction costs and the resources that are available for this purpose and possibilities of the country in the field of modern technologies. At each engineering construction is needed so most effectively and as economically as possible to use the technology in a given geological an environment. Must not be forgotten fundamental requirement such as functionality of the object. The publication presents some selected case studies that address the problems of soft rocks. This is an issue of clayey and loam (silt) soils, organic soils, peat and lacustrine deposit. Loams are according to European code EN ISO 14 688-1 known as silt, hereinafter referred to as loam.

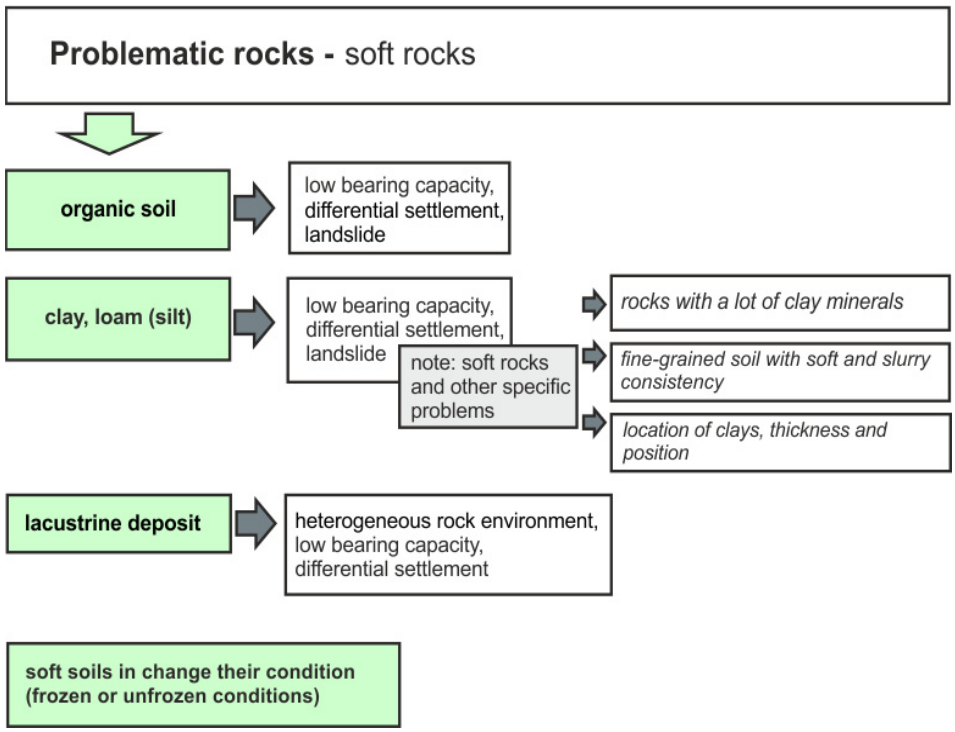

Fig. 1. Scheme - soft rock.

1. Problems of clay and loam soils

In connection with the existence of clay and loam, soils may arise multitude of problems that have a negative impact on the foundation engineering or existing construction. The most frequent problem arises in terms of shear strength and landslide.
Clays are unconsolidated sediments. Clays are classified according to the method of their formation. This is a residual clays and relocated clays. Relocated clays are divided into marine, glaciofluvial, glacial, lacustrine, fluvial, proluvial and colluvial according to their way of relocation. According to the character of the clay component is divided into montmorillonitic clays, kaolin clays and illite clays. Problematic clays include the materials with a high proportion of clay minerals. Furthermore, there are fine-grained soil with a soft and slurry consistency. Significant is the position of clays, but also contain of loam and their thickness. Claystones are formed by partial consolidation of clays. The claystone are represented primarily kaolinite and illite.
Loams may be of different origin, which influences their properties. It may be called a slope loams that occur on the slopes. Then there are the loam accumulated through glaciers, whose typical occurrence as in the Czech Republic in

Ostrava region. Their origin is glacial. The third type is alluvial loam that occurs near rivers and inundation areas. They are often with an admixture the organic component.
One of the most frequent problems of clay foundation soils are at risk of landslides. Frequent stimulus to initiate of landslides is heavy rainfall.
Problems of slope movements also occur in eastern Honolulu on the island of Oahu. This is stated in the publication of Wan and Kwong [8]. The authors studied issue of clay and loam rocks, which lies on rocks of volcanic origin, represented by weathered basalt. The local clay belongs to the group of montmorillonite and smectite. The characteristic properties of montmorillonite are the possibility of expansion, i.e. adsorption of water between the layers. These clays have a very good basis to shrinking and swelling. They are also characterized by low shear strength. There is also a group represented by amorphous clay minerals that form a coating on crystalline mineral particles. Amorphous clay minerals usually have a high plasticity and ability to shrinkage and swelling [8].
The method of jet grouting can be effective solution stabilization of the slopes and improvement properties of these soils.
Significant initiator of landslides in clay rocks is the presence of steep slopes, heterogeneity of sediments with the presence of clay, fluvial erosion at the foot of the slope and a large the amount of precipitation. The presence of groundwater, surface water that infiltrates into the soil and increases its pore pressures lead to the destabilization of slopes. Human intervention plays an important role in most landscapes. The effects of these factors examined authors Eilertsen et al. [3] in northern Norway. Hazardous are also called sensitive clays. This is caused the groundwater flow and the presence of sand particles.
Sensitive clays are of marine origin. These clays are gradually reducing the strength due to leaching of ions. This is due to either infiltration of rainwater or artesian water. These landslides may occur even on relatively flat areas and a very large territory. However, occasionally there are sensitive clays that were deposited in brackish and fresh water. Composition of sensitive clays and their susceptibility to sliding is fundamental to understanding their behaviour. Chemical composition of pore water, mineralogy, geotechnical properties, and other parameters were studied by the authors in Sweden [1], in Baltic Sea region.

2. Problems of organic soils

Organic soils can be characterized as type of soft soil, which includes peat. Peat is comprised of fibrous organic material. They are formed by the decomposition of mosses, trees, various plants located in marshes or other wet areas under oxygen deficiency. Organic soils are characterized by a number of adverse properties. Organic soils are soft, compressible and permeable, have low shear strength and always contain a certain proportion of organic particles. The existence of organic soils brings in connection with the engineering construction a number of problems. Especially in combination with excessive precipitation which can lead to landslides, low bearing capacity or different settlement.
Problems of organic soils were studied in the publication by [2] in northern Scotland, the Shetland Islands. Peat cover has very high tensile strength in depth with various cracks and fissures. Described was also the presence of macropores and zones in peat through which infiltrate the water. The assessment of the susceptibility of these surface peat soil to sliding is very difficult. This is caused very high heterogeneity of the environment and associated with a high variability of geotechnical characteristics and also different hydrogeological characteristics. The range of slope displacements that are included here are very rare. Great Britain and Ireland recorded a number of negative impacts not only on engineering constructions. In connection with peat solifluction in Slieve Bearnagh, Co. Clare in Ireland, there was a mass movement with a volume of 9000 m^3 for example. It was caused by the construction of forest road. Occured to pollution Annacarriga River and killing up to 40,000 salmon and trout. As has been mentioned as very large landslides occurred in southern Mainland, in the Shetland Islands in Scotland due to extreme rainfall. The impact of this event achieved considerable damage to infrastructure and property. Other problems due to extreme rainfall in combination with peat became in Dooncarton Mountain in Pollatomish, Co. Mayo, Ireland. The consequences are damage to infrastructure, loss of property livestock but also a number of socio-economic impacts in the affected areas. Building the wind farm initiated the movements of peat, but to a much lesser extent. There was also contamination Owendalulleegh River and Lough Cutro where the killing 50000 fish and contamination of water supplies. Further, it caused the loss of more than 10 hectares of forest and a large range of socio-economic problems in the affected area. It happened in Derrybrien, Slieve Aughty, Co. Galway, Ireland [2].
As is apparent from previous cases, in peat occurs landslides caused by engineering activities. Character of extent of

the landslides in these soils is very special.
The risk also creates the admixture of organic soils. It also threatens the realization of small constructions, such as residential houses. Good knowledge of the foundation conditions is therefore essential. Damages caused by construction on these soils with low bearing capacity are often irreversible. Most of such objects as mentioned above are performed on the piles. In addressing each particular system of housing it is important to select the optimum combination of economic and technical solutions. Construction on these soils with low bearing capacity is therefore inappropriate. Extent of built-up agglomerations is increasing. That is why construction must often be carried out in unsuitable foundation soils. This leads to the need for development of new construction methods for the safe and suitable building foundation on these soils.
These building area are found in many places around the world as described in the publication [9]. In the USA is peat in 42 states, for example. These foundation soils are also located in Canada or in Russia, it covers large areas. These soils are also located in Southeast Asia, Malaysia or Indonesia, Japan, Bangladesh and China [9]. These problematic organic soils including peat can form directly the foundation soil, or it can occure as an admixture in a particular proportion, or may be located at a greater depth and to be covered by other layers.
The geotechnical characteristics of organic soils from the viewpoint of foundation engineering are described by [6]. To understand the behaviour and the possibility of using a suitable stabilization of these soils, it is important to know the number of porosity, specific gravity, moisture, bulk density, shear strength and compressibility. Based on this knowledge, it is possible to choose the appropriate method for their stabilization. These include stabilization by cement columns, fibre reinforcement and chemical stabilization by grouting of sodium silicate, cement grouting and many others. Content of organic soil and its composition is specific in each location in depending on the origin of the fibres, the degree of humification of peat and temperature. Organic soils have quite specific properties in contrast to inorganic soils and their geotechnical properties. Compression is much greater in organic soils. The compressibility of peat is influenced by factors such as fibre content, porosity, natural water content, the arrangement of soil particles and the chemical bonds [6].
Improving the properties of these soils is not easy. It is therefore recommended replacing soils, foundation building on piles, or use of chemical additives on improve their properties.

3. Problems of other soft rock

Building constructed on soft soils is very problematic and require special measures. As already mentioned, this is a peat soils, soft clays, or organic soil, and others. If a soil is not well explored and is not used suitable method improved soil properties or stabilized against the potential negative effects, there may be problems with different settlement for example. In the case of line constructions such as roads, it can be influenced through dynamic effects caused by transport. It lead to cracks in the roads, in roadway, it creates wavy or bumps surface of roads.
In west coast of Malaysia, Batu Pahat district is engineering constructions in interaction with soft soils. Constructions, respectively construction of roads in Malaysia faced with problems very often wave road surface. This issue is in publication [7]. Foundation soil consists mainly of soft soils. It is a wetland area with a significant proportion of soft soils of marine and coastal alluvium. Very important is the appropriate choice of design features that prevent the negative effects of these soft soils. During the construction of roads occur problems in interface road and bridge construction. It is associated with the occurrence of differential settlement in soft of underlying strata. Bridge aproach slab consists of a concrete transition roadway between the bridge deck and asphalt carpet. This should reduce the dynamic effects of cars on the bridge. It is aggressiveness of drivers, driving speed and thus the dynamic effects increase. Differential settlement is the case of contact with the bridge and the road, it is very common phenomenon. Stiffness of the material plays a very important role. Different types of bridge approach slab will react different depending on the type of dynamic load differently [7].

4. Lacustrine sediments and soft sediments in connection with the change of status

Sediments that arise in water environment are called lacustrine sediments. The sediments in the lakes may have heterogeneous composition. The important role played climatic conditions that influenced area in the past. Also important are the present climatic conditions as well as geological environment. Most often, lacustrine sediments are composed of fine sand, marl and clay. Peat originated in the lakes that overgrowing with vegetation. It exist also lakes, which may temporarily or periodically dry up.

Changing climatic conditions reflected on the potential change in the properties of foundation soils. It can be slaking of soil, swelling and the number of negative properties. There may be a change of state in the frozen environment, the defrosted environment, or in the case of extreme drought and heat. Seasonal fluctuations of weather cause in many places in various parts of the world damage on roads, pavements but also on objects. Given that constructions responding to changing characteristics of the foundation soil is very important to focus on the development of new materials with improved geotechnical properties that will resist these influences. Especially an area with extensive buildings, damage can be annually very high.
In Canada because of damage caused by expansive soils quantified as significantly higher than the damage from other natural hazards. This is specified in the publication [5]. The authors focused on properties of glacilacustrine clays and their properties in relation to engineering objects. There were studied geology and climatic conditions. For these glacilacustrine clays were determined soil properties in laboratory, the properties of the pore water, the susceptibility to swelling and consolidation. In the studied samples was represented smectite, illite, chlorite, kaolin in 50% of the sample. Smectite was occurring in 35%, albite presence of 9%. Na-plagioclase, which is susceptible to chemical weathering, was leached in a bearing in a small amount [5].
Problems of soft subsoil are often combined with a number of other factors, which can further worsen its properties.
A problem of soft environment, lying on the bedrock aquifer that consist lacustrine sediment was occurred in the Czech Republic. It is case of reconstruction of the road between the towns of Jihlava - Třebíč. Part of the road segment is led in soils with very low bearing capacity while the road was built on a high embankment. It was therefore expected of the susceptibility of soils to heterogeneous deformation behaviour [4].

5. Conclusion

Development of technologies in the field of soil improvement and the development of new design elements is constantly evolving. At present, it can be more or less construct buildings on rocks, which were previously unsuitable for building foundations. It is a question of the construction costs that are for this purpose available and the possibility of the state in terms of modern technology. Each geological environment has its own specifics. At each engineering construction is needed so most effectively and the most economical to use the technology. It is also important to meet the expectations for functionality of the object. New areas are still annexation. It is include not only human dwellings, but also industrial objects that a gradually decreasing number of suitable areas with favourable foundation soils.
The publication focused on soft rocks that are a worldwide problem. It is a soils that can negatively affect the building construction and therefore it is necessary to them pay more attention. Create a simple diagram and showing the basic problems from around the world will help to understand the basic problems of soft rocks. Each case study is realized in different climatic, morphological, geological, but also the economic conditions. This fact should be borne in mind.
Among some of the most problematic soft rocks so we can include clay and loam rocks. For these rocks, it is important to expect the possibility of different settlement, landslides formation, or low bearing capacity. It is especially the case of soil with soft or slurry consistency.
Another type of problematic soft rocks is organic soils. The risk of organic soils is also related with occurrence of landslides, differential settlement or low bearing capacity. Organic soils also include peat. In addition, these soils are soft, they also have a high compressibility, and permeability and low shear strength.
The geological environment is often very heterogeneous. Type unfavourable foundation soil can thus be combined with each other. This means that these soils cannot be strictly separated in practice.
Group of lacustrine sediments also bring with it a series of negatives. In particular, it is a highly heterogeneous environment. As with the previous soft rocks may be problems with different settlement and low bearing capacity. Most often, they are composed of fine sand, marl and clay. Every geological environment also reacts to climatic conditions. Especially in areas where there is significant seasonal changes. It can be a thawing of the soil or drought or rainy season. The soil under these conditions enormously burdened.

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